International Journal of Marine Engineering Innovation and Research, Vol. 10(4), Dec. 2025. 1097-1106 (pISSN: 2541-5972, eISSN: 2548-1479)

Design Development Study Of Mini Trash Skimmer Boat A22 With Packing Technology In East Flood Canal

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(Received: 19 October 2025 / Revised: 19 October 2025 /Accepted: 20 October 2025 / Available Online: 1 December 2025)

***Abstract*— Garbage is a significant source of water pollution, particularly in the East Flood Canal (BKT) river. This study develops the design of the Mini Trash Skimmer Boat A22 as a practical solution for waste collection in polluted waters. The vessel adopts a catamaran hull to ensure stability and efficiency in skimming operations. With principal dimensions of 3.5 m in length, 2 m in breadth, and 0.8 m in depth, it accommodates a waste bin of approximately 0.4 m³. A conveyor system integrated with hydraulic press technology is applied to compact garbage, thereby increasing storage capacity. Resistance analysis using the Holtrop method in Maxsurf shows that at a speed of 21.26 knots, the vessel experiences a maximum resistance of 8.1 kN, corresponding to an engine power requirement of 8.83 kW. The boat is further equipped with an autonomous navigation module to support operational efficiency and powered by Lifepo4 lithium batteries with one-hour endurance. The results highlight that incorporating packing technology enhances waste-handling capacity, while the combination of catamaran stability and automation makes the Mini Trash Skimmer Boat A22 a promising approach for reducing water pollution in urban waterways.**

Keywords— Water Pollution, Catamara Design, Trash Skimmer Boat, Hydraulic Press, Autonomous Vessel, Packing

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I. INTRODUCTION

Rivers are globally significant freshwater ecosystems that play a crucial role in sustaining the environment and human life. In Jakarta, rivers are increasingly affected by pollution originating from both wastewater discharge and plastic waste. approximately 75% of rivers and major bays in the country are classified as heavily polluted [1].

Furthermore, the volume of plastic waste generated in Indonesia has continued to increase over the past decade. Total waste generation from 202 regencies and municipalities across the country reached 19.45 million tons. Food waste was the most dominant component (41.55%), followed by plastics (18.55%), wood or branches (13.27%), paper or cardboard (11.04%), metals (2.86%), textiles (2.54%), glass (1.96%), rubber or leather (1.68%), with the remaining 6.55% consisting of various other materials [2].

In the East Flood Canal (Banjir Kanal Timur, BKT), waste management is carried out through manual cleaning operations along a 1,200-meter stretch. Sanitation workers patrol and maintain approximately 400 meters of the canal per day, resulting in garbage collection being performed every three days. Consequently, waste accumulated within the EFC is removed at three-day intervals.

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Pollution in rivers is primarily caused by surrounding industrial, commercial, and domestic activities. As a result, rivers are contaminated with various types of waste, particularly plastics, which not only threaten aquatic ecosystems but also pose negative impacts on public health and generate unpleasant odors that affect nearby communities. To mitigate the adverse impacts of waste pollution in the East Flood Canal, innovative approaches to river management and cleaning are required. One proposed solution is the utilization of a Mini Trash Skimmer Boat.

A catamaran vessel also experiences resistance when operating in water. The resistance acting on a catamaran-based trash skimmer is a combination of several hydrodynamic forces that hinder its motion [3]. Due to its two slender and parallel hulls, a catamaran generally produces lower wave-making resistance compared to a monohull, as the hull form minimizes wave generation. [4]. However, the larger wetted surface area leads to higher frictional resistance because of the increased contact surface between the hull and water. In addition, form resistance arises from the hull geometry and the vessel's superstructure, particularly at the bow section designed to collect waste [5]. Auxiliary components such as conveyors, collection arms, and surface filters also contribute to additional resistance, especially when these systems are in operation or carrying loads of garbage. Therefore, the design of a catamaran trash skimmer must carefully balance hydrodynamic efficiency with waste collection performance to ensure vessel stability [6].

One of the key features of the trash skimmer boat design is the integration of packing technology. This system enables the vessel to collect and compact waste with high efficiency, thereby reducing the volume required for storage and transportation [7]. The application of packing technology in the trash skimmer boat enhances the efficiency of river-cleaning operations by utilizing a hydraulic system to compress the collected waste. The design parameters may vary depending on the vessel's capacity, operational requirements, and the specific conditions of the East Flood Canal (BKT) [8]. Furthermore, because the vessel incorporates packing technology, stability considerations are also taken into account to ensure that the Mini Trash Skimmer Boat can safely accommodate the intended waste load.

Moving to the context of the Trash Skimmer Boat, it is evident that a dedicated vessel design is required to effectively collect waste from the water surface and thereby contribute to the reduction of environmental pollution [9]. Conventional manual collection methods in the East Flood Canal (BKT) have proven insufficient to handle the continuous inflow of debris, particularly plastics and organic waste, which accumulate at a rapid rate. To address this issue, the researchers propose the development of a purpose-built trash skimmer boat. The vessel is conceived with a minimalist yet functional design concept, emphasizing simplicity, stability, and cost-effectiveness while maintaining operational efficiency. Such a design is expected to serve as a practical solution for mitigating the waste problem in the BKT by enabling systematic, continuous, and more efficient waste collection [10].

Furthermore, the integration of a catamaran hull form provides enhanced stability and deck area, making it suitable for accommodating waste-handling equipment such as conveyors and hydraulic compaction systems. By aligning design objectives with the specific environmental and operational conditions of the BKT, the trash skimmer boat can represent a sustainable approach to urban river waste management [11].

A trash skimmer boat is a type of specialized vessel designed to collect waste from various bodies of water, including rivers, lakes, seas, and canals. This vessel is classified as a workboat and is typically designed with a catamaran hull configuration, enabling it to efficiently capture and transport waste from aquatic environments. Some trash skimmer boats are equipped with conveyor belt systems that collect floating debris from the water surface [12]. The vessel's design is adapted to its operational requirements and includes a storage bin to hold the collected waste. Several cities around the world, such as Baltimore, Washington D.C., Fort Lauderdale, New York, and Chicago, as well as certain regions in Indonesia, have already implemented the use of trash skimmer boats.

Figure. 1. Mini Trash Skimer Boat

II. METHOD

2.1. Research Material

The research utilized both primary and secondary data as the main sources of analysis. The primary data were directly obtained through field surveys conducted at the research site, which specifically involved the collection and documentation of waste data from the BKT area in 2025. These data served as the fundamental basis for understanding the actual conditions and characteristics of waste accumulation in the field. In addition to the primary data, the study also incorporated secondary data that were gathered indirectly from various reliable sources. The secondary data included waste input records at TPST for the years 2022–2023 obtained from the National Waste Management Information System, ship design data derived from previous research studies, as well as annual average waste volume statistics reported by the Environmental Agency of DKI Jakarta Province. The combination of both primary and secondary data provided a comprehensive overview, enabling a more accurate analysis and strengthening the validity of the research findings.

2.2. Design Method

Several design methods were employed in this study. The main design activity focused on developing a trash skimmer vessel with a catamaran hull configuration, equipped include a conveyor system and a waste packing unit. The principal dimensions of the vessel were determined by adapting data from an existing ship as a reference. Following the initial design process, ship resistance calculations were performed. To obtain the principal dimensions, comparative data from reference vessels were collected and analyzed, which then served as the basis for calculating the main dimensions of the designed vessel. Once the principal dimensions were established, the resistance and battery power requirements were subsequently calculated to ensure the feasibility of the design.

In addition, several software tools were utilized to support the design process, namely:

1. AutoCAD 2018 (Student Version): used to create the lines plan drawings and the General Arrangement (GA) of the designed vessel [13].
2. Maxsurf Modeler 12: applied to assist in modeling the catamaran hull form and to facilitate resistance and stability calculations of the vessel [14].
3. SketchUp: employed for developing the three-dimensional (3D) model of the hull, building upon the previously generated hull form [15].
4. SolidWorks: used to design and further develop the main components of the trash skimmer boat, including the waste conveyor system, hydraulic press (functioning as a waste compactor or packing machine), and the waste storage compartment (trash bin) [16].

Furthermore, several calculation methods were applied in the research. The Parent Design Approach was adopted to utilize and adapt existing ship designs into a more specific configuration suitable for the purpose of this study. The Holtrop method was applied to perform resistance calculations. Additional calculation methods were also used to design and evaluate the performance of the conveyor system, the hydraulic press for waste compaction, as well as to determine the required battery capacity for vessel operation.

2.3. Calculation Methods

2.3.1. Parent Design Approach Methode

One of the widely recognized methods in ship design is the comparative approach, which involves selecting an existing vessel as a reference, particularly one that shares similar characteristics with the ship to be developed. This method provides designers with a practical benchmark, enabling them to analyze, compare, and adapt proven design elements rather than starting entirely from scratch.

Within this framework, the Parent Design Approach serves as a systematic strategy aimed at optimizing the utilization of an existing design, often referred to as the *parent design*. The essence of this approach lies in its ability to adapt a design that has already demonstrated effectiveness in real-world applications and reconfigure it to meet new operational demands. This process typically involves careful modification of certain aspects, such as hull form, capacity, stability, or propulsion systems, while retaining the core structural and hydrodynamic features that have already been validated in practice [17].

The advantage of employing a parent design lies in its established track record and reliability. Since the parent vessel has undergone performance validation and operational testing, it provides a strong and credible foundation for further development. By leveraging this prior knowledge, the design process becomes not only more efficient but also more robust, as the risks associated with untested concepts can be minimized. Moreover, the Parent Design Approach enables designers to align new vessel specifications with targeted operational conditions, ensuring that the final product achieves both functional and economic feasibility [18].

In the context of modern naval architecture, the Parent Design Approach is particularly relevant for projects that require a balance between innovation and proven reliability. Rather than engaging in a costly and time-consuming trial-and-error process, designers can focus on refining an existing framework, tailoring it to unique environmental, technical, and operational requirements. This makes the Parent Design Approach a valuable methodology for sustainable and practical ship design, particularly when efficiency, safety, and adaptability are prioritized.

2.3.2. Holtrop Methode

In this study, the Holtrop method is employed, which is commonly applied in resistance calculations for various types of vessels such as rescue ships, cargo ships, and fishing vessels [19].

Rsub =(1 + k1) + RAPP + RW + RB + RTR + RA (1)

To determine the Froude Number (Fn) of the designed vessel, the following formula is applied [20].

$$Fn = \frac{Vs}{\sqrt{g}\ x\ LWL} \tag{2}$$

To determine the residual resistance coefficient (CF), the designed vessel refers to the graphical method provided. The value of CF is obtained by correlating the prismatic coefficient (CF), the length to displacement ratio $L/\nabla^{1/3}$, and he Froud humber (Fn) of the designed ship [21].

After applying corrections to $10^3 C_R$ the next step is to sum all the components of $10^3\ C_R$. From these calculations, the value of $10^3\ C_R$ is obtained. Subsequently, the Reynolds Number (Rn) is determined in order to evaluate the flow characteristics around the designed vessel [21]. The Reynolds number is calculated using the Reynolds formula as follows:

$$Rn = \frac{Vs\ x\ LWL}{v} \tag{3}$$

As for the total residual resistance coefficient represents the cumulative value of all residual resistance components acting on the ship's hull after correction. It is obtained by summing the corrected values of $10^3 C_R$ [22]. This coefficient plays a significant role in estimating the overall resistance performance of the vessel.

$$C_F = \frac{0{,}075}{(Log10Rn-2)-2} \tag{4}$$

The total resistance coefficient is defined as the summation of all resistance coefficients that influence the performance of the designed vessel. The contributing coefficients that form the total resistance coefficient include: Residual resistance coefficient (10^3CR), Friction resistance coefficient (10^3CF), Appandage resistance coefficient (10^3CA), Air resistance coefficient (10^3CAA) and Rudder resistance coefficient (10^3CAS) [21]. In which the formula is:

$$RT = CT \times \frac{1}{2} \times \rho \times WSA \times Vs^2 \quad (5)$$

2.3.3. Waste Capacity Calculation Method

The calculation of waste capacity for a trash skimmer boat is conducted by taking into account several key factors, including the vessel's dimensions, the type of waste to be collected, and the onboard handling systems, such as conveyors and hydraulic presses. These factors are critical to ensure that the vessel operates efficiently and can manage the expected waste load without overflow or operational disruption [23].

The first step in the calculation is to determine the available storage volume specifically allocated for waste collection. This volume is derived from the dimensions of the boat and the specially designed compartments intended to accommodate waste. These compartments are strategically positioned and designed to optimize space usage while maintaining the vessel's stability and balance during operation [23].

After determining the storage volume, the density of the waste is considered. Waste materials collected by the trash skimmer typically consist of a mixture of plastics, leaves, and other solid debris, each with different densities. By accounting for these variations, designers can estimate the total mass of waste that the vessel can safely carry, which is crucial for both structural design and operational planning.

Based on the dimensions of the waste collection bin, the waste volume can be calculated using the standard formula for volume:

$$\text{Volume} = \text{Length} \times \text{Width} \times \text{Height} \quad (6)$$

This calculation provides the theoretical maximum volume of waste that the vessel can accommodate. To ensure practical usability, designers may also include a safety margin to account for irregularly shaped debris, compaction efficiency, and potential variations in waste density.

By integrating the vessel's structural dimensions with operational considerations and material characteristics, this method ensures that the trash skimmer boat is designed with sufficient capacity to handle the expected waste load effectively. This approach not only maximizes operational efficiency but also contributes to sustainable urban waterway management by enabling continuous collection and transport of floating debris.

2.3.4. Conveyor Design

A. Estimated Conveyor Capacity

The calculation of conveyor capacity on a trash skimmer boat is essential to ensure that the waste handling system operates efficiently and is capable of managing the volume of waste encountered during operations. Proper sizing of the conveyor ensures smooth transportation of collected debris from the water surface to storage bins, minimizing operational delays and preventing system overload.

To calculate the conveyor's carrying capacity, the general formula commonly used is as follows:

$$Q = A \times v \times \rho \quad (7)$$

Where:
Q = Conveyor capacity (mass or volume per unit time)
A = Cross-sectional area of the conveyor belt carrying the waste
v = Conveyor belt speed
ρ = Bulk density of the waste material

This formula allows designers to estimate the maximum amount of waste the conveyor can transport per unit time, taking into account the physical dimensions of the belt, the operational speed, and the characteristics of the collected waste. Additionally, adjustments may be made to account for variations in waste type, moisture content, or compaction, ensuring that the conveyor system is both efficient and reliable under real operational conditions.

Proper conveyor capacity calculation is a critical aspect of the overall design of the trash skimmer boat, as it directly influences the vessel's ability to maintain continuous waste collection, optimize storage utilization, and reduce downtime during operations

B. Forces Acting on the Conveyor

To calculate the forces acting on a conveyor (such as the one used on a trash skimmer boat), the following formula can be applied:

$$Fg = W \cdot \sin(\theta) \quad (8)$$

Where:
Fg = Gravitational force acting on the material along the conveyor (N)
m = Mass of the material (kg)
g = Acceleration due to gravity (m/s²)
A = Cross-sectional area of the conveyor belt (m²), calculated as:

$$A = \text{Conveyor Length} \times \text{Conveyor Width} \quad (9)$$

θ = Conveyor inclination angle (degrees)

This calculation allows designers to determine the component of gravitational force acting along the conveyor's slope, which is critical for sizing the drive system and ensuring smooth material transport. By understanding the forces involved, engineers can select appropriate motors, design structural supports, and prevent potential overloading or slippage of the conveyor system.

C. Calculation of Frictional Force on the Conveyor

The frictional force on a conveyor serves to move the material placed on the conveyor belt while ensuring that it remains securely in position throughout the conveyor's travel. This prevents slippage or spillage, allowing the transportation process to proceed smoothly and efficiently, without interruptions that could hinder the operational performance of the conveyor system.

The required formula is as follows:

$$Ffriction = \mu \times W \quad (10)$$

Where:
Ffriction = Frictional force required to move the

		material (N)
μ	=	Coefficient of friction, which depends on the type of rubber belt and the condition of the material (e.g., wet, damp, organic waste, or wet trash). Typical values range from 0.4 to 0.7.
W	=	Weight of the material per unit length of the conveyor (N/m)

By calculating the frictional force, designers can ensure that the conveyor belt provides sufficient traction to transport the waste material effectively. This calculation is crucial for determining the motor power, selecting appropriate belt materials, and designing system components that prevent slippage, ensuring continuous and reliable operation of the trash handling system.

D. Conveyor Motor Power

The power requirement of the conveyor motor can be calculated using the followin formula:

$P = Ftotal \times v$ (11)

Where:

P	=	Required motor power (kW)
Ftotal	=	Total force acting on the conveyor, which includes the weight of the material and the frictional force
Ftotal	=	*W + Ffriction*
v	=	Conveyor belt speed (m/s)

This calculation allows designers to determine the motor capacity necessary to move the waste material efficiently along the conveyor without slippage or overload. By considering both the weight of the material and the frictional resistance, the formula ensures that the motor selected can sustain continuous operation under expected load conditions, thereby optimizing the performance and reliability of the trash skimmer boat's waste handling system.

2.3.5. Hydraulic Press Machine Design

The design of an integrated waste handling system on a trash skimmer boat involves careful consideration of waste collection, transportation, and compaction processes to ensure efficient operation. The first step is to determine the waste storage capacity, which depends on the vessel's dimensions, the type of waste to be collected, and the design of storage compartments. The total storage volume is calculated based on the dimensions of the waste bin, using the standard volume formula: Volume = Length×Width×Height. For example, a compartment measuring 0.42 m × 1.4 m × 0.92 m has a volume of approximately 0.54288 m³.

This volume is further adjusted by a compaction ratio to determine the effective amount of waste that can be stored and processed efficiently, accounting for variations in waste density and material characteristics, such as plastics, leaves, or organic debris.

The next step involves the design and capacity estimation of the conveyor system, which transports collected waste from the water surface to storage bins or the hydraulic compaction chamber. The conveyor capacity is determined using the formula

$Q = A \cdot v \cdot \rho$ (12)

where *A* is the cross-sectional area of the belt, *v* is the belt speed, and *p* is the bulk density of the waste material.

Additionally, the forces acting on the conveyor are analyzed, including the gravitational component along the belt:

$Fg = W \times \sin\theta$ (13)

and the frictional force required to prevent slippage,

$Ffriction = \mu \times W$ (14)

where μ is the coefficient of friction based on belt and material characteristics, and *W* is the weight of the material per unit length. These forces are combined to determine the total force acting on the conveyor, which in turn is used to calculate the required motor power:

$P = Ftotal \times v$ (15)

This ensures that the conveyor operates efficiently, transporting waste without interruption while preventing slippage or overload.

Finally, the hydraulic press system is designed to compact the collected waste, reducing its volume and maximizing storage efficiency. The volume of the compaction chamber is first calculated, and the effective compactable waste volume is determined using the compaction ratio. The hydraulic power required is calculated as:

$Phydraulic = Q \times P/\eta$ (16)

where *Q* is the hydraulic pump flow rate, *P* is the system pressure (typically 1500 psi for effective compaction), and η is the pump efficiency.

To drive the hydraulic system, the electric motor power is then determined by dividing the hydraulic power by the motor efficiency:

$Pelectric = Phydraulic / \eta motor$ (17)

ensuring continuous and reliable operation of the compaction process.

By integrating these calculations, the trash skimmer boat is designed with a fully coordinated waste handling system, where storage, conveyor transport, and compaction are optimized for efficiency, reliability, and sustainability. This systematic approach ensures that waste collection operations proceed uninterrupted, minimizes overflow, and allows for effective management of urban waterways, contributing to both environmental protection and operational performance of the vessel.

2.3.6. Battery Capacity Calculation

Calculating the battery capacity is essential to ensure that the vessel can operate for a sufficient period without running out of power, especially when using electric motors or other electrical systems such as conveyors or hydraulic systems. The required battery capacity can be calculated using the following formula:

Battery Capacity (Ah)=Battery Voltage (V)/Required Power (W)

(18)

Where:

Battery Capacity (Ah) = Required capacity of the battery in ampere-hours
Required Power (W) = Total electrical power needed by the systems onboard
Battery Voltage (V) = Operating voltage of the battery

This calculation ensures that the selected battery system can sustain continuous operation of all electrical components, including conveyors, hydraulic presses, and other onboard equipment, for the expected duration of the vessel's mission. Proper battery sizing is critical for operational reliability and helps prevent interruptions in waste collection and processing operations.

2.3.7. Operational Tim Calculationn

The operating time of the trash skimmer boat is determined based on the battery capacity and the total power required by the vessel, including electrical systems such as the conveyor and hydraulic press. The operational time can be calculated using the following formula:

$$T = \frac{E}{P} \tag{19}$$

Where:
T = Operational time (hours)
E = Energy available from the battery (Watt-hours)
P = Total power required by the vessel (Watts)

This calculation ensures that the vessel can operate continuously for a sufficient duration without interruptions due to power limitations. By considering both the total energy available and the energy consumption of all critical systems onboard, designers can optimize battery capacity and ensure reliable performance during waste collection operations. Proper estimation of operational time is crucial for planning missions, scheduling recharging, and maintaining consistent efficiency in environmental cleanup efforts.

III. RESULUT AND DISCUSSION

3.1. River Data

The East Flood Canal (BKT), also known as Banjir Kanal Timur, is a pivotal infrastructure project aimed at alleviating flooding in East and North Jakarta. Spanning approximately 23.6 kilometers, the canal was constructed to divert excess water from several major rivers, including the Cipinang, Sunter, Buaran, Jatikramat, and Cakung rivers, which have historically contributed to significant flooding events in these regions. The canal serves a drainage system covering an area of 207 km² and is designed to reduce flooding in 13 vulnerable areas of East and North Jakarta [24].

Despite its intended purpose, the BKT faces operational challenges, particularly concerning the accumulation of waste within the canal. Between October and December 2021, the volume of collected river waste reached 121,433.53 m³, averaging approximately 40,477 m³ per month. With an average depth of 5–6 meters, this accumulation translates to an estimated daily deposit of 3 m³, predominantly consisting of household waste such as plastics, bottles, and beverage containers [25].

The presence of such substantial waste not only hampers the canal's capacity to effectively manage floodwaters but also poses environmental and public health risks. The accumulation of plastic debris obstructs water flow, leading to increased flood risks and the degradation of water quality. Furthermore, the decomposition of organic waste contributes to the emission of greenhouse gases, exacerbating climate change impacts.

Addressing these challenges requires a multifaceted approach, including enhanced waste management practices, public awareness campaigns, and infrastructural improvements to prevent waste accumulation in the canal. By implementing such measures, the efficacy of the BKT in mitigating flooding can be significantly improved, contributing to the resilience of Jakarta's urban infrastructure.

3.2. Determination of Principal Dimensions

In determining the principal dimensions of the vessel, the parent design method was employed. This method utilizes a reference vessel with similar characteristics to the ship being designed, serving as a benchmark to guide the design process.

For the development of the trash skimmer boat, an in-depth analysis of existing vessel data was conducted to ensure that the new design would comply with the required operational and technical standards. By examining these reference vessels, it is possible to derive the optimal dimensions that balance stability, capacity, and maneuverability.

Based on present data from an existing vessel that served as the basis for determining the principal dimensions. The reference vessel has a length of 5.5 meters, a height of 1.1 meters, and a draft of 0.27 meters, providing a foundation for scaling the new design [26].

The principal dimensions of the designed vessel, as summarized in paragraph before, serve as the foundation for creating a detailed three-dimensional model of the ship. The main dimensions include a length between perpendiculars (L/B) of 3.5 meters, a beam (B) of 2 meters, a height (H) of 0.8 meters, and a draft (T) of 0.3 meters. These values were derived from the analysis of existing vessels using the parent design method and were adjusted to meet the operational requirements of a trash skimmer boat.

3.3. Ship Modeling

The design of the trash skimmer boat was carried out using Maxsurf Modeler software, which allows for the generation of both the lines plan and the general arrangement (GA) of the vessel. The lines plan provides a detailed depiction of the hull shape, while the 3D model of the hull enables visualization and precise adjustments of the vessel's geometry to ensure optimal hydrodynamic performance.

In addition to the hull design, the vessel is equipped with a conveyor system intended to transport waste from the river surface to the packing area. The conveyor is designed to withstand harsh environmental conditions and plays a crucial role in enhancing the efficiency of waste management in waterways. Based on the operational requirements of the trash skimmer boat, the conveyor was designed with a length of 1.44 meters and a width of 1.4 meters. Its carrying capacity depends on multiple factors, including the conveyor belt speed, belt width, and the type of waste being transported, typically measured in tons per hour (t/h) or cubic meters per hour (m^3/h).

After performing the necessary calculations, the conveyor system was determined to have a transport capacity of 432 tons per hour. The required motor power for the conveyor was calculated and in the total force acting on the conveyor was calculated as 16,480.8 N, and the belt speed was set to 0.1 m/s. By multiplying these values, the required motor power was obtained as 1,648.08 W, which is approximately 1.65 kW.

This calculation ensures that the motor has sufficient capacity to move the specified amount of waste efficiently, allowing the conveyor system to operate reliably under typical river conditions while supporting the vessel's primary function in waste collection and management.

The A22 trash skimmer boat is equipped with a hydraulic press (packing machine), which is used to compact collected waste by applying hydraulic pressure. This system reduces the volume of the waste, enabling more efficient waste management and allowing the trash skimmer boat to accommodate a larger quantity of waste. The main dimensions of the hydraulic press is: length of 0.42 meters, height of 1.4 meters, and width of 0.92 meters.

To determine the compacted waste capacity on the vessel, the compaction ratio was taken into account, which in this design is 3:1. This means that the volume of waste after compaction is reduced to one-third of its original volume. The hydraulic press is able to compact approximately 0.1809 m^3 of waste within its chamber.

Based on the operational requirements and calculations, the electrical power required for the hydraulic press in this trash skimmer boat design is approximately 0.907 kW, ensuring that the system can operate efficiently and reliably during continuous waste collection operations.

3.4. Ship Operation

The The A22 Trash Skimmer Boat is equipped with a comprehensive autonomous operational module that integrates and manages all critical systems onboard, ensuring smooth and efficient performance in riverine waste collection operations. The autonomous module is designed to synchronize the hydraulic system, waste detection sensors, anti-collision sensors, and propulsion system, enabling the vessel to operate with minimal human intervention while maintaining optimal safety and efficiency.

The selected autonomous system for the A22 is the Sea Machines 300, a state-of-the-art maritime automation solution designed for unmanned or semi-autonomous vessel operations. This system allows the boat to operate autonomously, while also providing a remote control interface for monitoring and manual intervention when necessary. The Sea Machines 300 comprises two primary components: the Onboard Cabinet, which serves as the central control unit and distributes electrical power to all electronic and autonomous systems; and the Remote User Interface (RUI), a device that allows operators to control, monitor, and receive real-time feedback from the vessel from a remote location. This setup ensures not only operational efficiency but also enhances safety by allowing real-time response to dynamic environmental conditions [27].

For efficient waste collection, the A22 Trash Skimmer Boat is also equipped with an Artificial Intelligence Recognition and Identification System (Al-RIS). This system uses AI technology to detect, identify, and track floating waste items in real-time, allowing the conveyor and hydraulic systems to target and process waste more effectively [28]. The electrical power requirement for the Al-RIS system is approximately 0.05 kW, which ensures minimal energy consumption while enhancing operational performance.

In order to prevent collisions with other vessels or obstacles and to increase situational awareness during navigation, the vessel also integrates the Seasight system, a maritime sensor suite designed to detect nearby objects and provide real-time data to the onboard autonomous system. This capability is critical in crowded waterways, as it ensures the safety of both the vessel and surrounding traffic. The electrical power requirement for the Seasight system is approximately 1 kW, allowing it to function continuously during operational hours.

Propulsion for the A22 Trash Skimmer Boat is provided by a Torqeedo CRUISE 6 electric motor with a rated power of 6 kW. This motor delivers sufficient thrust for smooth, controlled navigation even under loaded conditions, ensuring that the vessel can maneuver effectively while collecting waste. The combination of autonomous control, AI-assisted waste detection, anti-collision monitoring, and efficient electric propulsion allows the A22 to operate continuously and reliably, maximizing waste collection efficiency while reducing operational risks [29].

Overall, the integration of these advanced systems into the A22 Trash Skimmer Boat represents a holistic approach to modern urban waterway management. The vessel not only provides a robust solution for waste collection but also demonstrates the potential of autonomous technology to enhance maritime environmental management, operational safety, and resource efficiency in densely populated urban rivers.

No	Speed	Froude No. LWL	Froude No. Vol.	Holtrop Resist. (kN)	Holtrop Power (kW)
1	15	0,327	3,122	6,1	4,6806
2	15,25	0,333	3,174	6,1	4,8232
3	15,5	0,338	3,226	6,2	4,9695
4	15,75	0,344	3,278	6,3	5,1193
5	16	0,349	3,33	6,4	5,2724
6	16,25	0,354	3,383	6,5	5,4285
7	16,5	0,36	3,435	6,6	5,5874
8	16,75	0,365	3,487	6,7	5,7491
9	17	0,371	3,539	6,8	5,9132
10	17,25	0,376	3,591	6,9	6,0795
11	17,5	0,382	3,643	6,9	6,248
12	17,75	0,387	3,695	7	6,4183
13	18	0,393	3,747	7,1	6,5904
14	18,25	0,398	3,799	7,2	6,7639
15	18,5	0,404	3,851	7,3	6,9379
16	18,75	0,409	3,903	7,4	7,1117
17	19	0,414	3,955	7,5	7,2856
18	19,25	0,42	4,007	7,5	7,4594
19	19,5	0,425	4,059	7,6	7,633
20	19,75	0,431	4,111	7,7	7,8061
21	20	0,436	4,163	7,8	7,9786
22	20,25	0,442	4,215	7,8	8,1503
23	20,5	0,447	4,267	7,9	8,321
24	20,75	0,453	4,319	8	8,4905
25	21	0,458	4,371	8	8,6586
26	21,25	0,464	4,423	8,1	8,8251
27	21,5	0,469	4,475	8,1	8,9897
28	21,75	0,474	4,527	8,2	9,1524
29	22	0,48	4,579	8,2	9,3127
30	22,25	0,485	4,631	8,3	9,4706
31	22,5	0,491	4,683	8,3	9,6258
32	22,75	0,496	4,736	8,4	9,778
33	23	0,502	4,788	8,4	9,9271
34	23,25	0,507	4,84	8,4	10,0727
35	23,5	0,513	4,892	8,4	10,2147
36	23,75	0,518	4,944	8,5	10,3527
37	24	0,524	4,996	8,5	10,4865
38	24,25	0,529	5,048	8,5	10,6159
39	24,5	0,534	5,1	8,5	10,7406
40	24,75	0,54	5,152	8,5	10,8603
41	25	0,545	5,204	8,5	10,9747

Figure. 2. Resistance Analysist

3.5. Resistance Analysis

The hydrodynamic resistance of the designed trash skimmer boat was analyzed using Maxsurf, employing the empirical Holtrop method to estimate the total resistance and the corresponding propulsion power across the operating speed range. The Holtrop method, as implemented in Maxsurf, provides a practical and widely accepted approach for preliminary resistance prediction of displacement and semi-displacement hulls by combining frictional, residual and appendage resistance components.

The detailed Maxsurf output (Figure 2) indicates that at a design service speed of 21.25 knots the required propulsion power to overcome hull resistance is 8.8251 kW. This value is consistent with the Holtrop-based resistance estimate and was used as the principal check against the vessel's installed-power and system loads.

The vessel's auxiliary and operational loads were itemized as follows:

Conveyor motor: 1.65 kW

Hydraulic press: 0.000907 kW (≈0.907 W)

Other operational needs (electronics, sensors, autonomous system, lighting, pumps, etc.): 7.05 kW

Summing these contributions yields the total installed/required power in total 8.700907 kW.

Comparison with the resistance-derived propulsion requirement shows that the resistance power at 21.25 knots (8.8251 kW) slightly exceeds the calculated total installed power (8.7009 kW). Because the resistance-derived power is the propulsion requirement to maintain speed (and must be supplied in addition to auxiliaries in some sizing philosophies), this comparison indicates the design is close to the required margin. In practical design practice a small margin is usually required for transient conditions, added safety, and inefficiencies. Nevertheless, the Maxsurf / Holtrop result demonstrates that the hull form and installed power are in the same order of magnitude and that the installed systems will allow operation near the target speed—subject to verification in model tests or more detailed CFD/resistance analyses [30].

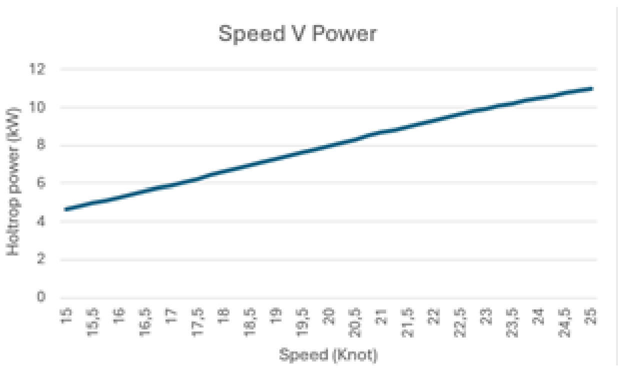

Figure. 3. Power VS Speed Graph

The The battery selection for the A22 Trash Skimmer Boat was determined based on the total power demand required to support its propulsion system, conveyor, hydraulic press, and other operational loads. The total energy consumption was calculated to be approximately 8.70 kW (8700.907 W) for one hour of operation. By applying the capacity formula at a system voltage of 42 V, the minimum theoretical requirement was found to be 207.16 Ah. However, to ensure operational reliability under real-world conditions—including inverter and controller inefficiencies depth-of-discharge limitations, and long-term degradation—a conservative capacity of 362 Ah was selected. For this purpose, the GNLi GN42V $LiFePO_4$ (Lithium Iron Phosphate) battery was chosen, with dimensions of 54 × 22 × 30 cm. $LiFePO_4$ technology was preferred because of its high cycle life, safety, thermal stability, and efficiency, making it suitable for continuous marine applications [31]. This configuration ensures that the trash skimmer boat can operate reliably within its design endurance while maintaining safety and energy efficiency in river waste management operations.

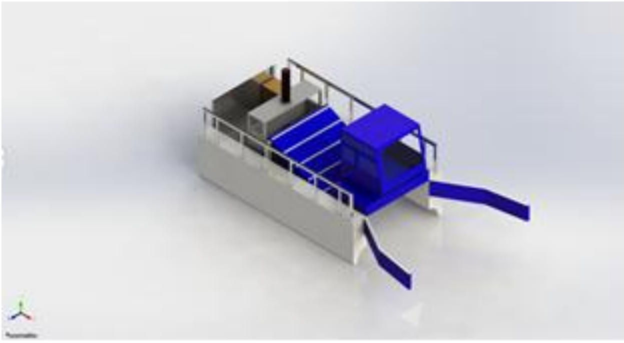

Figure. 4. A22 Mini Trash Skimmer Boat Design

IV. CONCLUSION

The development of the Trash Skimmer Boat A22 presents an innovative design aimed at addressing waste reduction in the Banjir Kanal Timur (BKT) area. The vessel has been constructed with a length of 3.5 meters and a beam of 2 meters, dimensions that allow for efficient maneuverability in riverine environments while maintaining sufficient capacity for waste collection. The design employs a catamaran hull configuration, which offers enhanced stability by utilizing two separated hulls, ensuring the vessel remains upright and secure during operation.

This hull design not only supports improved performance in waste collection but also ensures operational safety in varying water conditions. The boat is equipped with a dedicated waste storage bin of approximately 0.4 m^3, with bin dimensions of 1.26 m in length and 1.3 m in width, making it suitable for handling significant waste volumes collected during operation.

To optimize waste handling, the vessel integrates a conveyor system measuring 1.44 meters in length and 1.4 meters in width, with a calculated motor power requirement of 1.65 kW. This system facilitates continuous waste collection from the water surface and transfers it directly to the storage bin, thereby streamlining the waste management process. Furthermore, the design incorporates hydraulic press technology, enabling compaction of the collected waste into smaller volumes.

With dimensions of 0.43 meters in length, 1.4 meters in width, and 0.92 meters in height, the hydraulic press significantly increases the vessel's waste storage capacity, making the system more efficient and sustainable in long-term operations.

For operational control, the Trash Skimmer Boat A22 is equipped with the Sea Machines 300 autonomous module, which coordinates synchronization between onboard systems, including hydraulics, waste detection sensors (Al-ris), collision avoidance sensors (Seasight), and the propulsion system (Torqeedo Cruise 6). This integration allows the vessel to operate autonomously while still offering remote monitoring and control, thereby improving both efficiency and safety. The entire system is powered by a 48V Lifepo4 Lithium Battery, designed to provide sufficient energy for up to one hour of continuous operation.

In summary, the Trash Skimmer Boat A22 demonstrates a practical and sustainable approach to river waste management by combining an efficient hull form, advanced waste collection and compaction systems, and autonomous operational technology. This integration of design and technology highlights the vessel's potential as a scalable solution for urban waterways, contributing to environmental preservation and sustainable maritime engineering practices.

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